



U.S. Environmental Protection Agency

Pesticides: Topical & Chemical Fact Sheets

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Chlorine Dioxide

Health & Safety
Specific Chemicals
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The following fact sheet is part of a series relating to chemicals that may be used in Federal Anthrax decontamination efforts. EPA has approved these pesticides for use against anthrax only by authorized personnel according to the specific requirements of the applicable crisis exemption and approved decontamination plans. These chemicals are not intended for use by the general public.

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What is Chlorine Dioxide?

Chlorine dioxide (ClO_2) is an antimicrobial pesticide recognized for its disinfectant properties since the early 1900's. Antimicrobial pesticides are substances used to control harmful microorganisms including bacteria, viruses or fungi on inanimate objects and surfaces. In 1967, EPA first registered the liquid form of chlorine dioxide for use as a disinfectant and sanitizer. In 1988, EPA registered chlorine dioxide gas as a sterilant.

Chlorine dioxide kills microorganisms by disrupting transport of nutrients across the cell wall. Chlorine dioxide can be generated in a gas or liquid form and smells like chlorine bleach. Chlorine dioxide should not be confused with chlorine gas. They are two distinct chemicals that react differently and produce by-products that also have little in common.

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Antimicrobial Pesticides

Antimicrobial pesticides are substances used to control harmful microorganisms including bacteria, viruses and fungi on inanimate objects and surfaces primarily in indoor environments. Types of antimicrobial products have traditionally included sanitizers, disinfectants, and sterilants.

A "sanitizer" is a substance that significantly reduces the bacterial population in the inanimate environment, but does not destroy or eliminate all bacteria or other microorganisms.

A "disinfectant" is a substance that destroys or eliminates a specific species of infectious or other public health microorganism, but not necessarily bacterial spores, in the inanimate environment.

A "sterilant" is a substance that destroys or eliminates all forms of microbial life in the inanimate environment, including all forms of vegetative bacteria, bacterial spores, fungi, fungal spores, and viruses.

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EPA's Registration of Pesticides

Before a pesticide can be marketed and used in the United States, EPA must evaluate the pesticide to ensure that it meets federal safety standards. EPA grants a registration (or a license) for a public health pesticide product only after the Agency has reviewed efficacy and safety data to ensure that, when used according to the specific instructions on the label, the product is effective and does not cause any unreasonable adverse effects on human health or the environment. Such evaluation is particularly important for antimicrobial pesticides (sanitizers, disinfectants, and sterilants) which are used to reduce or eliminate microbial contamination.

The pesticide label provides specific safety precautions and use directions for handling or using the product. EPA has concluded that chlorine dioxide products registered to date have met federal standards for environmental and human health safety.

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Registered Uses for Chlorine Dioxide

• Registered Liquid and Gaseous Products

EPA first registered chlorine dioxide gas as an antimicrobial pesticide in the 1980s. Chlorine dioxide gas is registered for sterilizing manufacturing and laboratory equipment, environmental surfaces, tools, and clean rooms. It is also used in pharmaceutical research and production. Liquid chlorine dioxide formulations were first registered in the 1960's as disinfectants and are used on a variety of sites including pets; farm animals; bottling plants; food processing, handling and storage plants; and many others.

• Other Registered Uses

Chlorine dioxide gas and liquid formulations also have many other industrial uses including:

- bleaching pulp and paper
- bleaching textiles
- washing fruit and vegetables
- disinfecting flume water
- disinfecting meat and poultry
- disinfecting food processing equipment
- sanitizing water
- controlling odors
- treating medical wastes
- treating municipal water

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Applying Chlorine Dioxide

Pesticide products containing either **sodium chlorite** or **stabilized chlorine dioxide** are usually mixed with another "reactive" chemical - usually an acid - to produce chlorine dioxide in a liquid or gaseous state. The resulting mixture is applied within a specific sterilization or disinfection system. The liquid chlorine dioxide is then applied to hard surfaces with a sponge or mop or as a coarse spray. Chlorine dioxide gas is also generated on site and is released into a sealed treatment area where it remains for several hours before being removed. After the treatment is completed, the chlorine dioxide gas is neutralized with sodium bisulfite. The treatment may leave a fine residue, but it is not toxic.

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FIFRA Section 18 Emergency Exemptions and Anthrax

Under Section 18 of FIFRA, EPA "may exempt any federal or state agency from any provision of this Act if the Administrator determines that emergency conditions exist which require such exemption." Normally, a federal or state agency submits an application for a FIFRA exemption to EPA for review and approval. If EPA approves the request, it issues either a specific or a public health exemption, as appropriate. However, if the emergency is of such urgency that the federal or state agency does not have enough time to submit an application for exemption and wait for EPA's approval, then the federal or state agency may issue a crisis exemption, which is effective for 15 days. In order for the crisis exemption to be extended beyond 15 days, the federal or state agency must submit an application for exemption to EPA.

To handle all anthrax contamination cases as quickly as possible, the Agency has decided to issue all crisis exemptions itself. To obtain a crisis exemption from EPA for the unregistered use of a pesticide against anthrax, a state or federal agency must submit a written request describing the antimicrobial product(s) to be used; how, when and where they will be used; the data demonstrating efficacy of the product for the intended purpose; and how human health and safety will be protected. Prior to issuing the exemption, EPA will perform a multi-disciplinary risk assessment of the requested use, relying on data that they have supplied for the pesticide.

If, during this review, EPA notes any adverse human health or environmental concerns, EPA may deny the exemption request. If, however, EPA believes that the proposed use of an antimicrobial product will be effective and will protect human health and the environment, EPA will issue a crisis exemption. Moreover, if EPA determines that use of the product is needed beyond the

15-day use period, EPA will complete an application for a public health exemption on behalf of the requesting entity, which allows the crisis exemption to continue in effect until it is either withdrawn or EPA issues a public health exemption.

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Determination of Safety and Efficacy for Crisis Exemptions for Chlorine Dioxide

EPA has reviewed data related to safety and effectiveness before allowing an emergency exemption for liquid and gaseous chlorine dioxide to be used specifically for anthrax decontamination. Available published data suggest that

liquid and gaseous chlorine dioxide will reduce bacterial spore populations under specific conditions including concentration, pH, and contact time.

Based on this review, EPA issued crisis exemptions for the limited sale, distribution, and use of liquid and gaseous chlorine dioxide against anthrax. EPA has determined that the public health threat posed by the anthrax incidents constitutes a public health emergency of such immediacy that normal processing and review of a conventional public health exemption under FIFRA are neither prudent nor practical. Under the crisis exemption for **liquid chlorine dioxide**, registered products (containing sodium chlorite) may be sold or distributed only to employees of federal, state or local government agencies, or of the U.S. Postal Service, for anthrax cleanup. Crisis exemptions for **gaseous chlorine dioxide** (from certain sodium chlorite products) have been issued for use at the Hart Senate Office Building (November 30, 2001), to decontaminate the exterior of mail packages that have been received by U.S. government offices (February 26, 2002), and to test fumigation of lockers in a trailer at the U.S. Postal Service Brentwood Processing and Distribution Center, Washington, D.C. (June 21, 2002).

Since issuing the initial crisis exemption on November 9, 2001, EPA tested the effectiveness of liquid chlorine dioxide and found that it was effective on hard surfaces (500 milligrams per liter, at 30 minutes contact time), but not effective on porous surfaces (e.g., carpeting, chairs, couches, and other fabric surfaces) under the conditions of use specified in the Section 18 Crisis Exemption of November 9, 2001. On March 28, 2002, EPA amended the crisis exemption for liquid chlorine dioxide to limit its use to hard surfaces only. This amendment does not affect the results of the cleanups performed with liquid chlorine dioxide to date. At the cleanup sites where liquid chlorine dioxide was used, all porous surfaces were pre-treated and removed for final disposal at a facility capable of destroying any remaining spores. Liquid chlorine dioxide, along with other methods and technologies, continues to be effective against anthrax spores on hard surfaces.

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Emergency Use of Liquid Chlorine Dioxide in Anthrax Decontamination

Application of the pesticide products under the crisis exemption is limited to specific buildings or treatment sites identified by EPA or other federal, state, or local governmental authorities, or the United States Postal Service. Applications must be conducted according to use instructions from federal, state, or local emergency response personnel following a plan that includes the following steps:

- Pre-sampling to determine the extent of spore contamination at specific locations.
- Spot remediation of highly contaminated surfaces through HEPA filter vacuuming.
- Gross surface decontamination with liquid chlorine dioxide.
- Post-treatment sampling to determine that the anthrax decontamination has been effective.
- Re-treatment with liquid chlorine dioxide if viable spores are detected.

These steps apply to facilities where the treated surfaces will be reused or the facility will be re-occupied. These steps do not necessarily apply to wastes or debris intended for disposal in an appropriate facility.

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Applying Liquid Chlorine Dioxide

On March 28, 2002, the Crisis Exemption for liquid chlorine dioxide was amended to specify its use to decontaminate **hard surfaces only**. Applications must be conducted according to use instructions from federal, state, or local emergency response personnel following a plan that includes the following steps:

- Pre-sampling to determine the extent of spore contamination at specific locations.
- Spot remediation of highly contaminated surfaces through HEPA filter vacuuming.
- Gross surface decontamination using a liquid solution of chlorine dioxide under the following conditions:
 - only hard surfaces may be treated;
 - a rate of 500 mg/L liquid chlorine dioxide will be applied;
 - applications will be made at room temperature (68 degrees F, 20 degrees C); and
 - treatments will have a contact time of at least 30 minutes.
- Post-treatment, environmental sampling to determine whether viable anthrax spores remain.
- Re-treating with liquid chlorine dioxide if viable spores are detected.
- Post-treatment testing to determine that the anthrax decontamination has been effective.

Any remaining liquid chlorine dioxide must be removed from the treated areas of the building before people are allowed to re-enter. After treatment, experts must determine - through post-treatment sampling - that the treatment was effective before anyone is allowed back into the building.

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Applying Gaseous Chlorine Dioxide

Based on review of available data, EPA believes that gaseous chlorine dioxide can be used in a facility decontamination procedure that includes sampling, cleaning, treating, and re-sampling, followed by additional treatment if necessary. The crisis exemptions for gaseous chlorine dioxide issued for the Hart Senate Office building (November 28, 2001) and for the exterior of mail packages (February 26, 2002) involved products containing sodium chlorite as the active ingredient to generate gaseous chlorine dioxide on site, followed by post-treatment environmental sampling to confirm that the treated areas were free from anthrax spores (i.e., showing no growth when samples are cultured in the laboratory). The conditions of application are described below. These conditions did not necessarily apply to personal protective equipment and other debris that were further treated offsite.

Conditions of application:

- A minimum concentration 500-550 ppm chlorine dioxide gas was initially applied for a minimum of 12 hours, for a minimum total of 6,000 ppm-hours. Later, the concentration was increased to 750 ppm for a total of 9,000 ppm-hours.
- Applications were made at a minimum temperature of 70 degrees F; and
- Relative humidity was maintained at a minimum of 65%. On June 17, 2002, EPA issued a crisis exemption for the U.S. Postal Service to test gaseous chlorine dioxide fumigation of lockers in a truck trailer located at the Brentwood Processing and

Distribution Center
in Washington, D.C. The lockers in the test were not contaminated with *Bacillus anthracis*. Rather, they were set up to simulate the 3,000+ lockers inside the building that would need to be fumigated either together with the building or separately. The purpose of the test was to help determine the ClO₂ concentration and contact time would be necessary to obtain a successful decontamination of employees' lockers.

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More Information on Antimicrobial Pesticides

- [Background on EPA's Antimicrobial Pesticide Regulatory Program](#)

If you have general questions about the federal pesticide program browse the Web site, or contact EPA's pesticides office:

- Office of Pesticide Programs (OPP).
Tel: 703-305-5017
Fax: 703-305-5558
E-mail: opp-web-comments@epa.gov

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